

# Matched Field Inversion of Explosive Signals from the ASIAEX ECS Experiment

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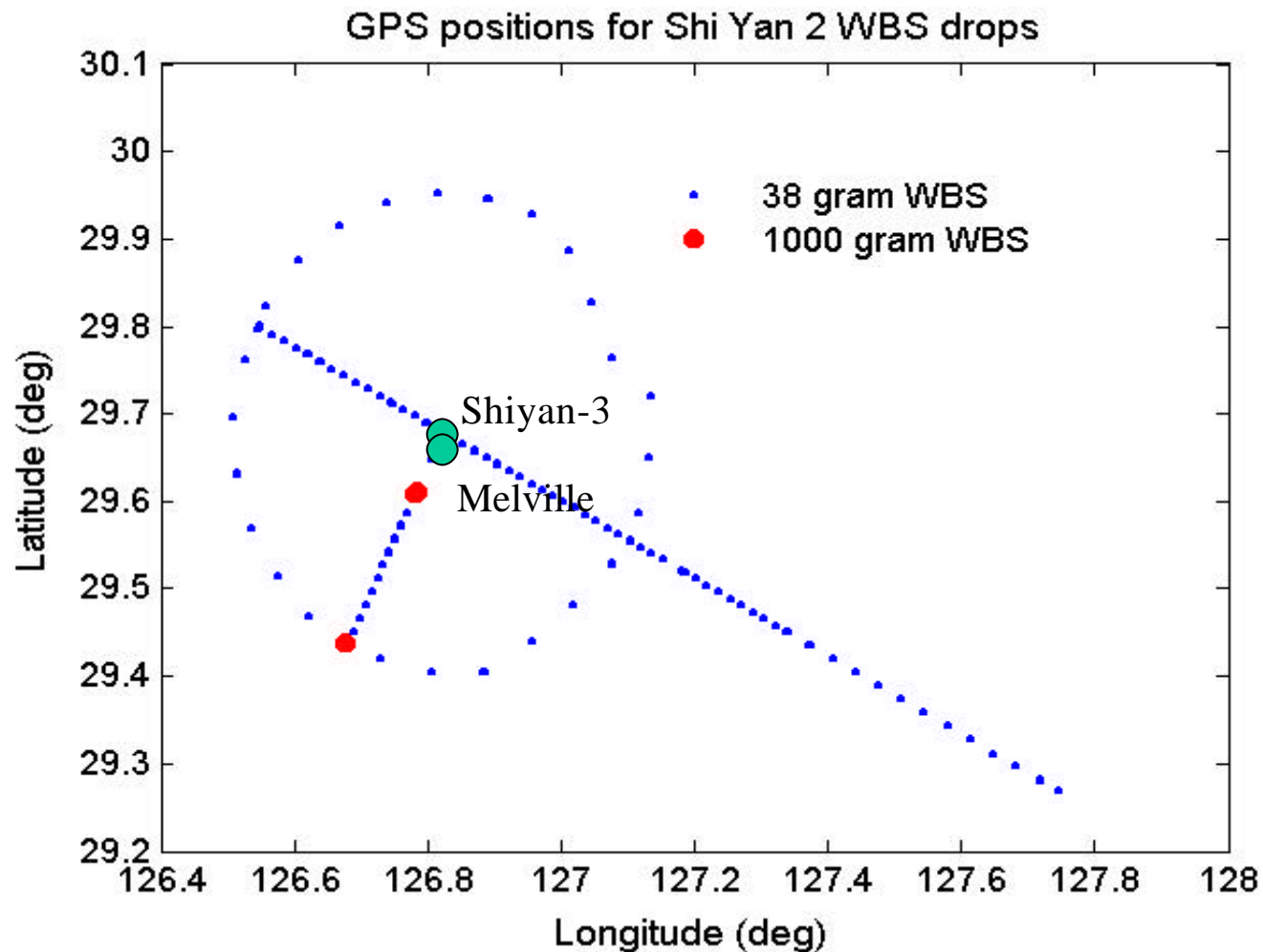
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Chinese Academy of Sciences

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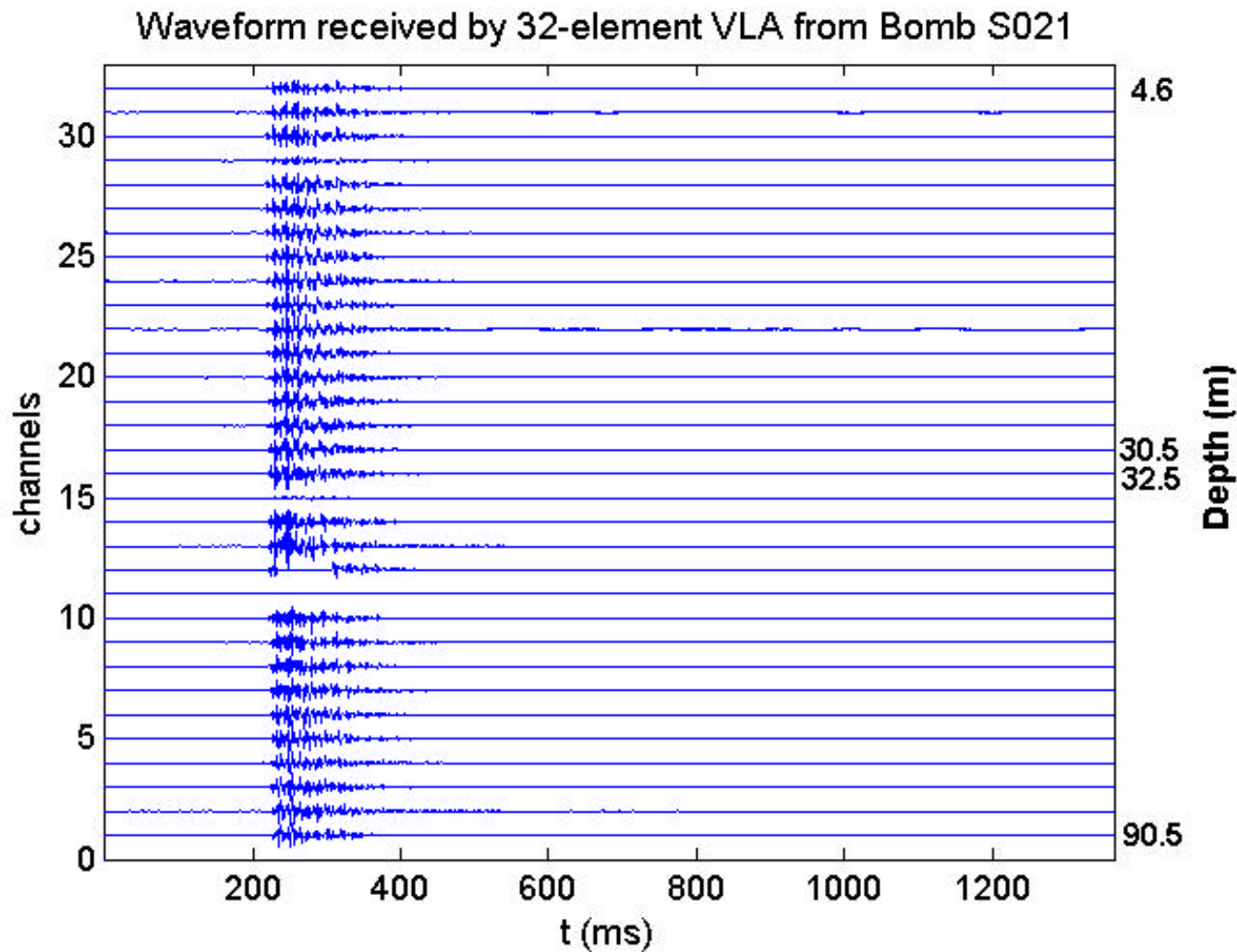
# Outline

- Introduction
- Matched Field Inversion
- TL Calculations and TL measurements
- Conclusion

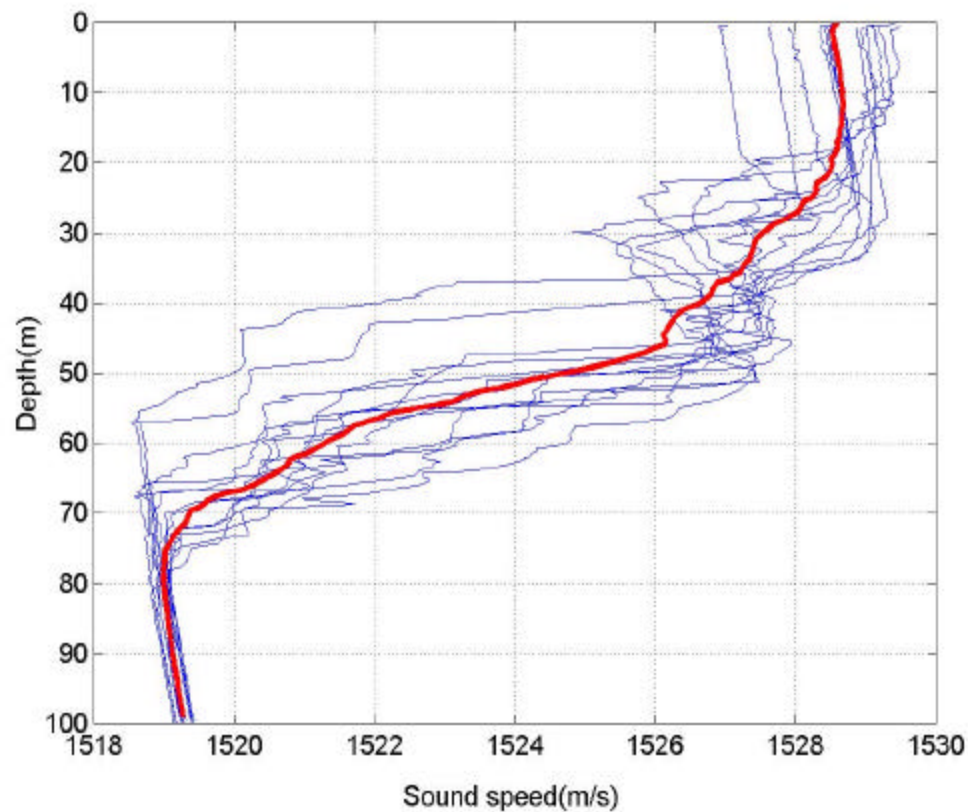
# WBS Propagation Measurements



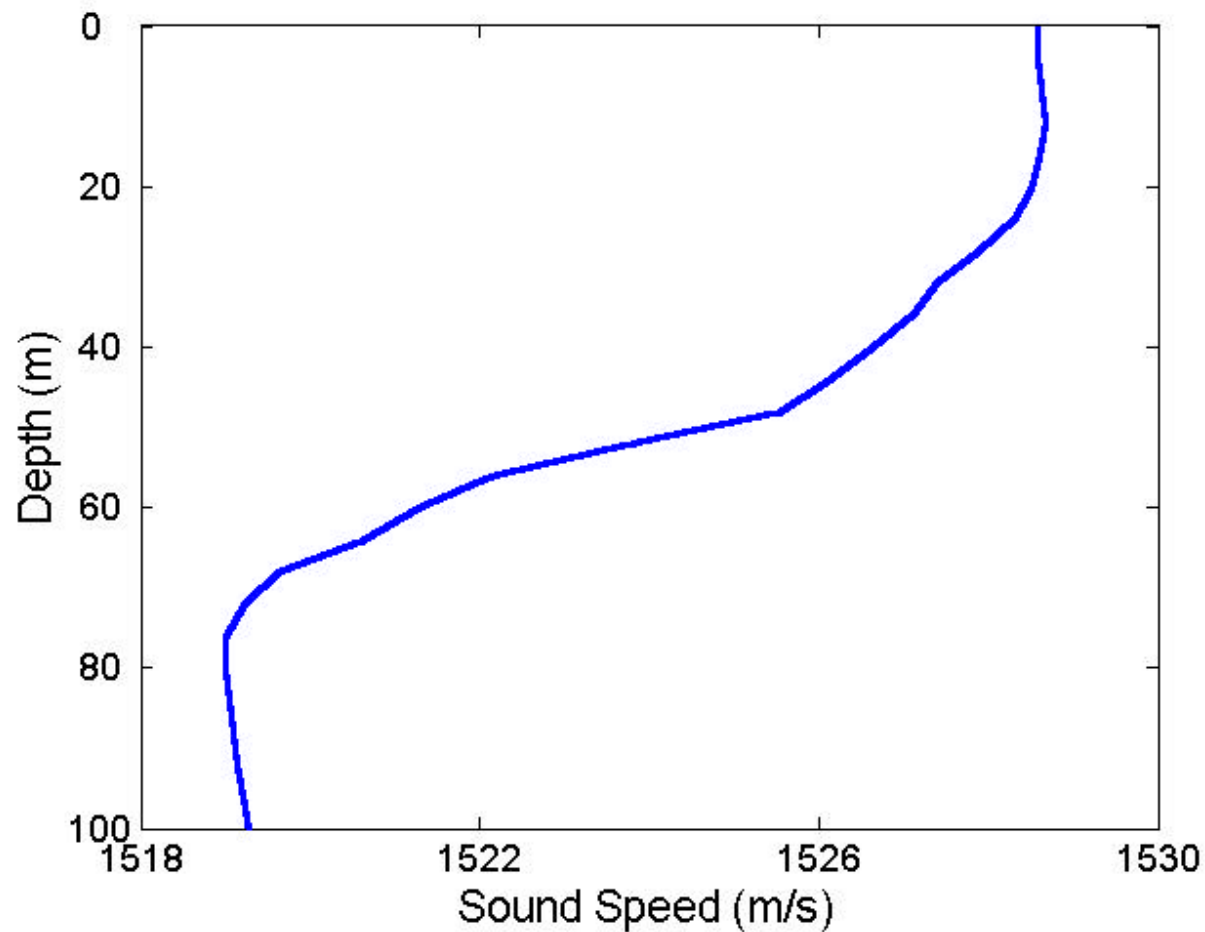
# The Bomb Signal Received by the VLA



# Sound Speed Profiles from Shiyan-3 CTD Casts during bomb signal propagation



# Sound Speed Profile used for Replica Field Computation



# The Matched Field Inversion using Multi-tone Signal

$$E(\mathbf{m}) = 1 - \prod_{j=1}^{N_f} \frac{\left| \sum_{i=1}^{N_D} p_{ij} q_{ij}^*(\mathbf{m}) \right|}{\sqrt{\sum_{i=1}^{N_D} |p_{ij}|^2 \sum_{i=1}^{N_D} |q_{ij}(\mathbf{m})|^2}}$$

$p_{ij}$  — Complex sound pressure measured by the  $i$ 'th hydrophone at frequency  $f_j$

$q_{ij}$  — Complex sound pressure calculated

Frequency range 120 - 360Hz, and NF = 6

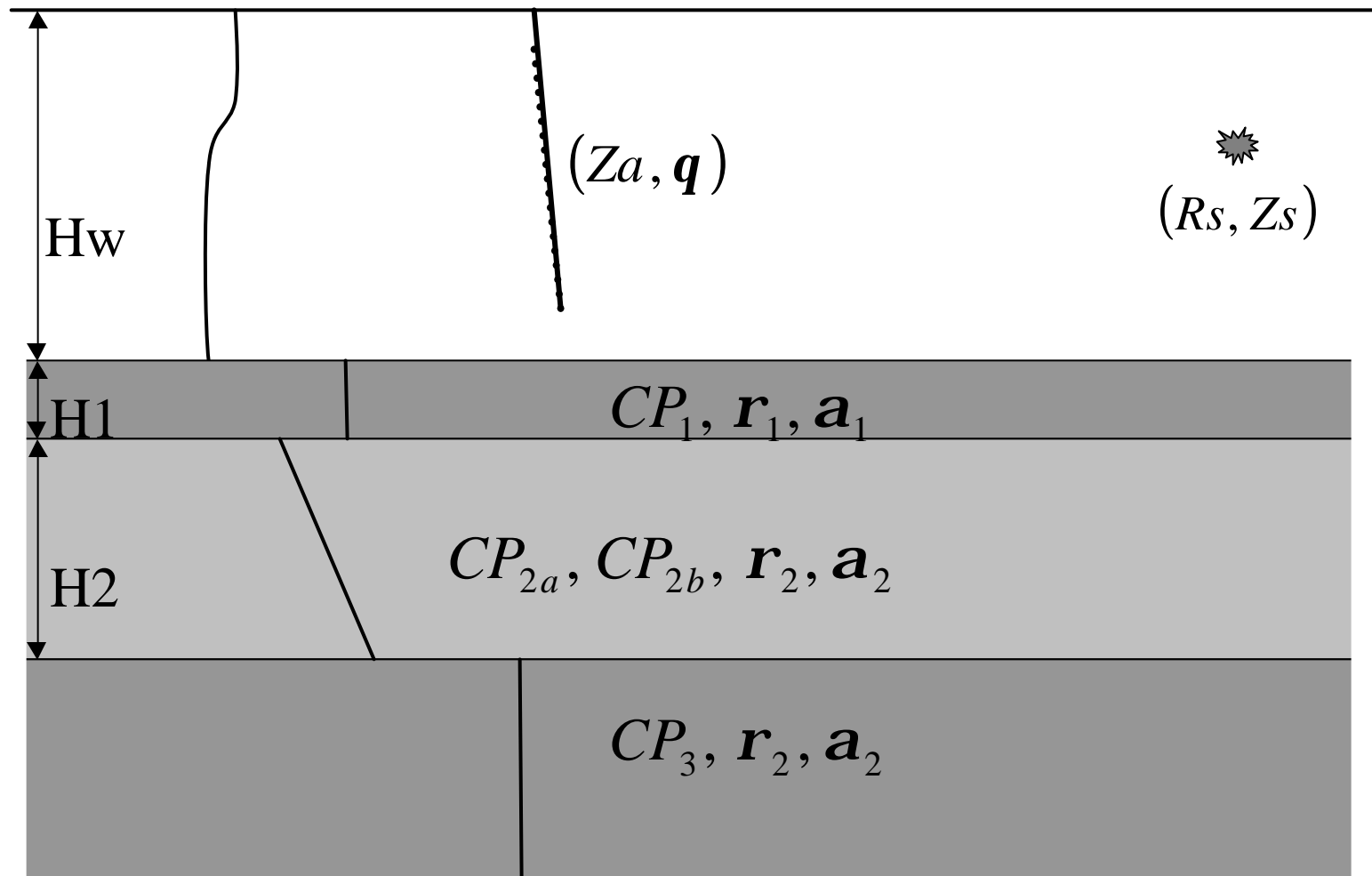


# The Genetic Algorithms for Inversion

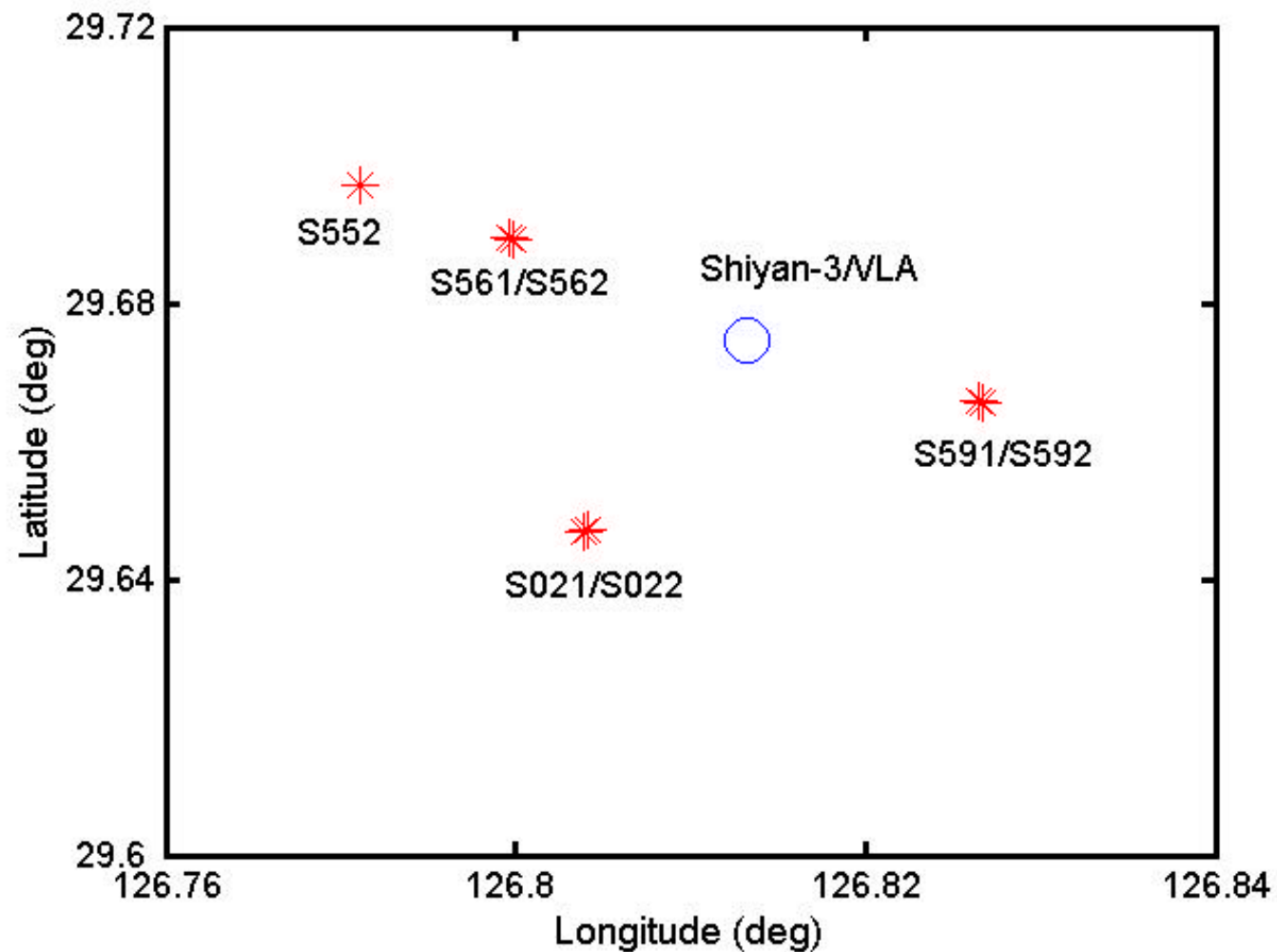
- Population size -- 80
- Reproduction size -- 0.5
- Crossover probability -- 0.8
- Mutation probability -- 0.05
- Number of generations for a GA run -- 150
- 6 independent GA runs for every bomb signal
- The best-fit parameter set is taken as inversion result

# Parameters to be Estimated

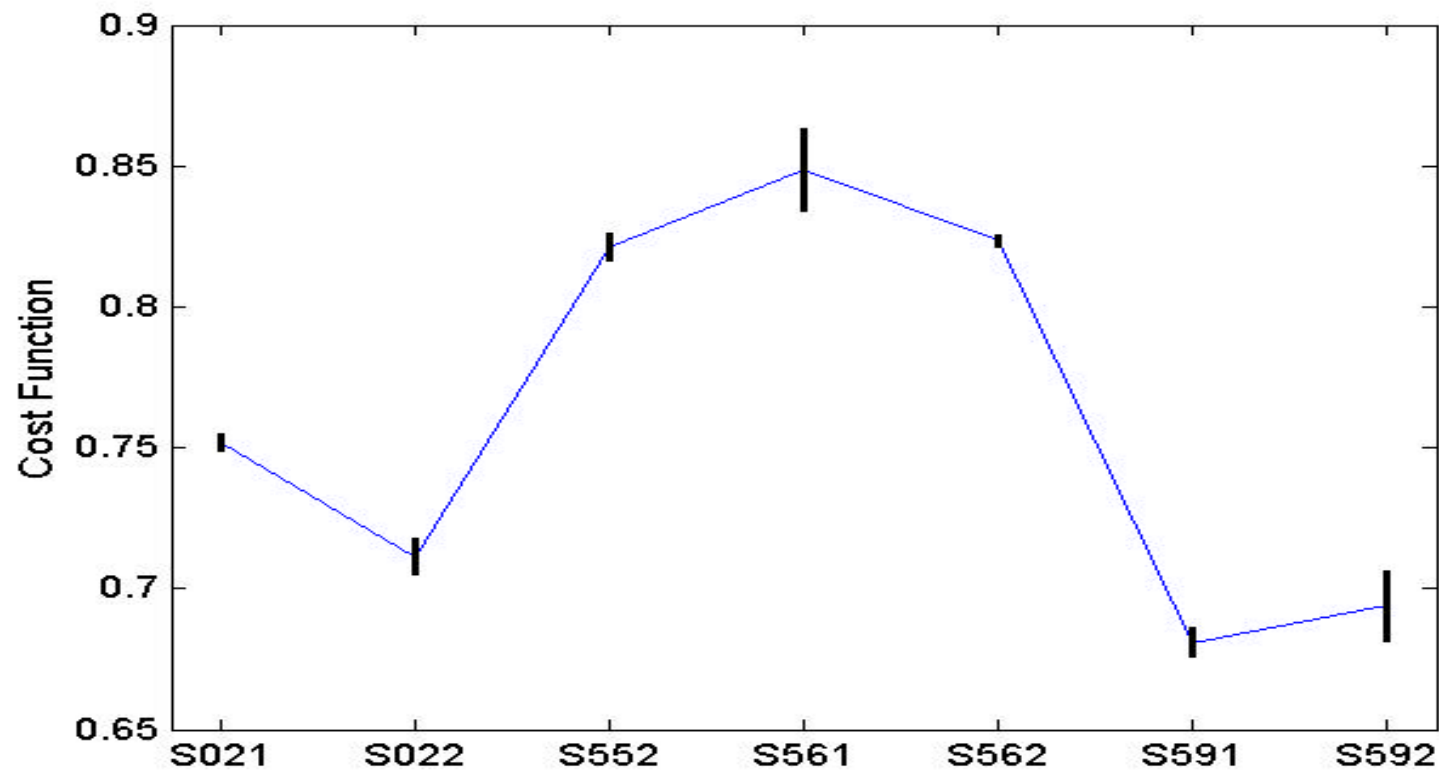
## -- Range-independent Model



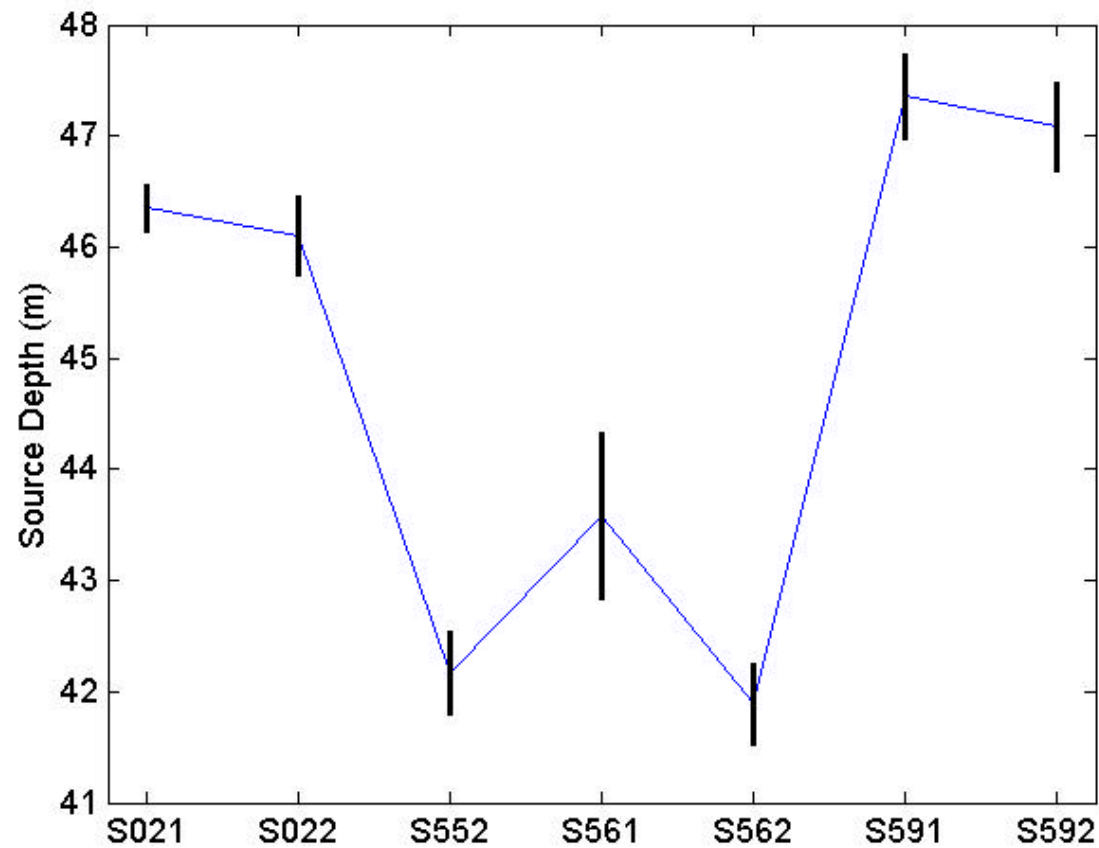
# The Bomb Signals used for Inversion



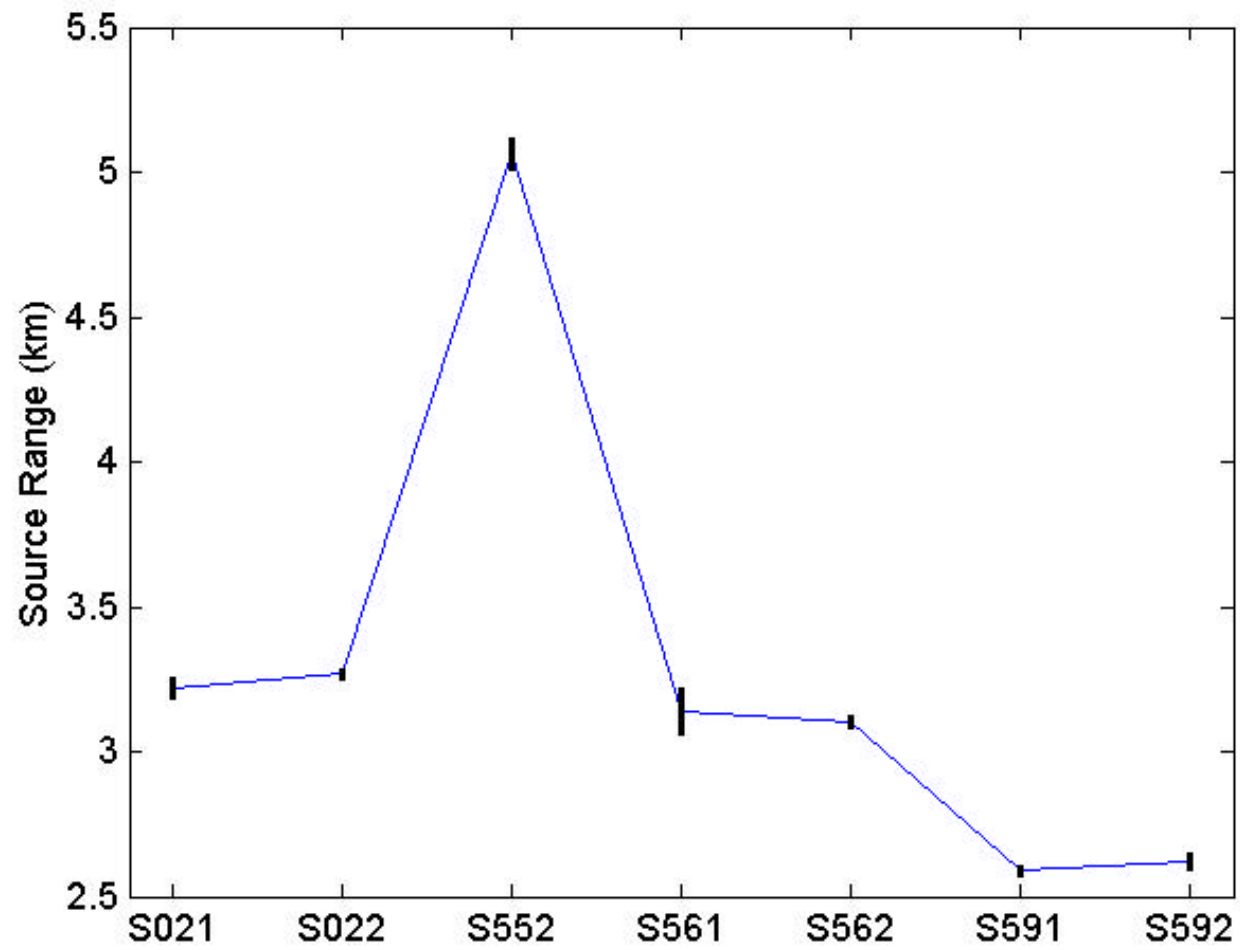
# Inversion Results – Cost Function



# Inversion Results – Source Depth

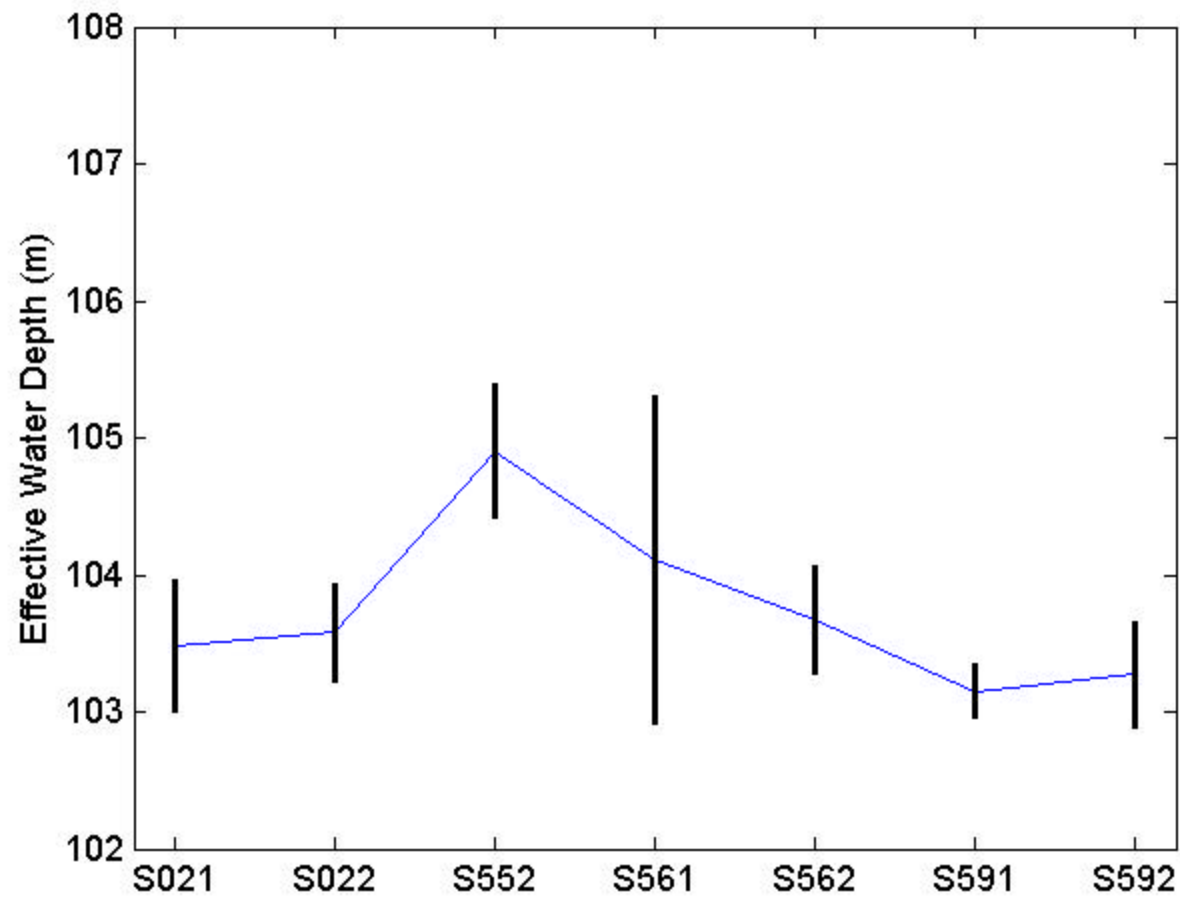


# Inversion Results – Source Range



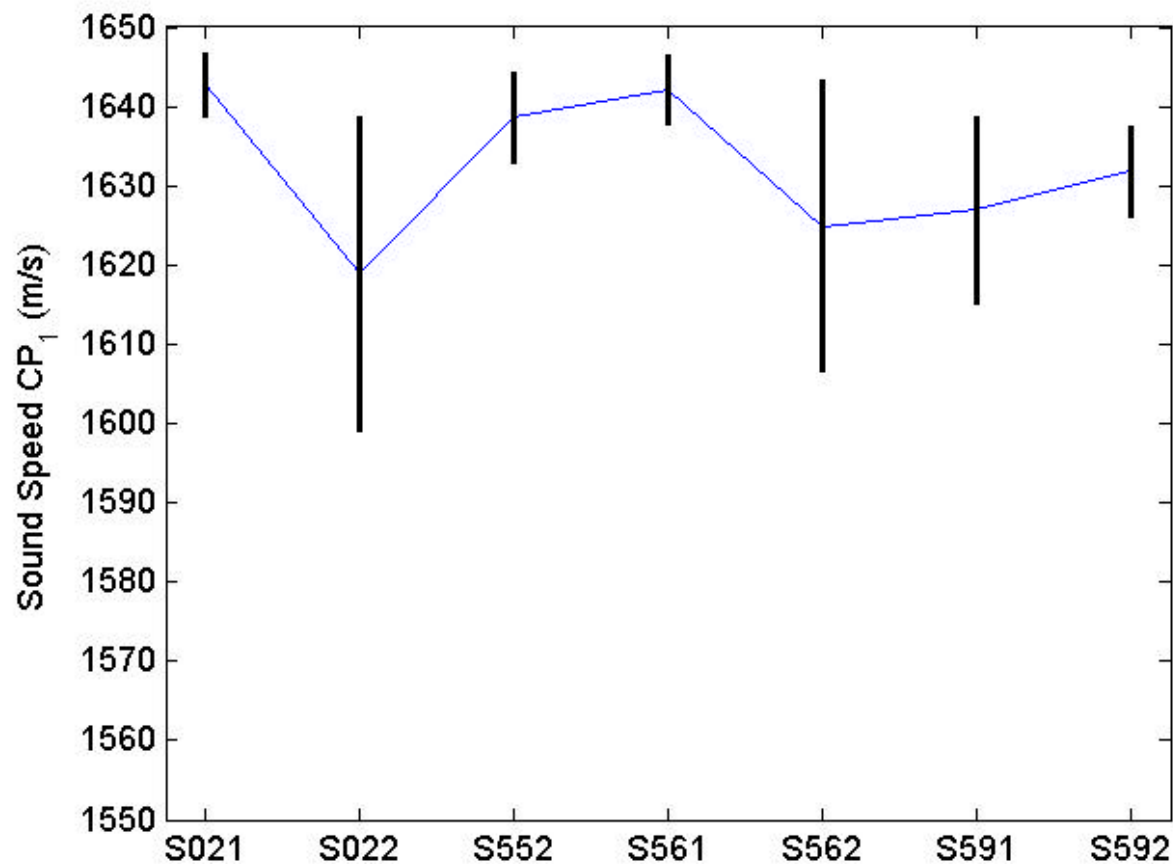
# Inversion Results

- Effective Water Depth



# Inversion Results

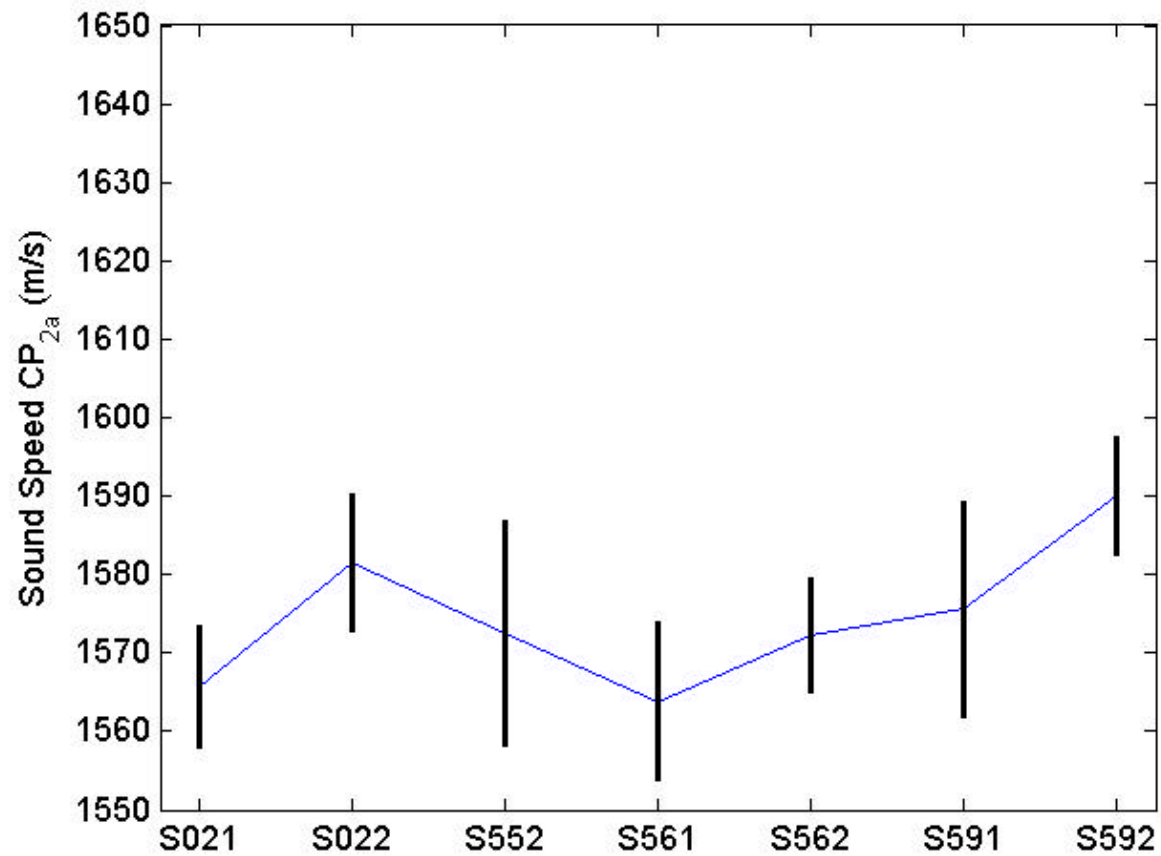
## – Surface Layer Sound Speed





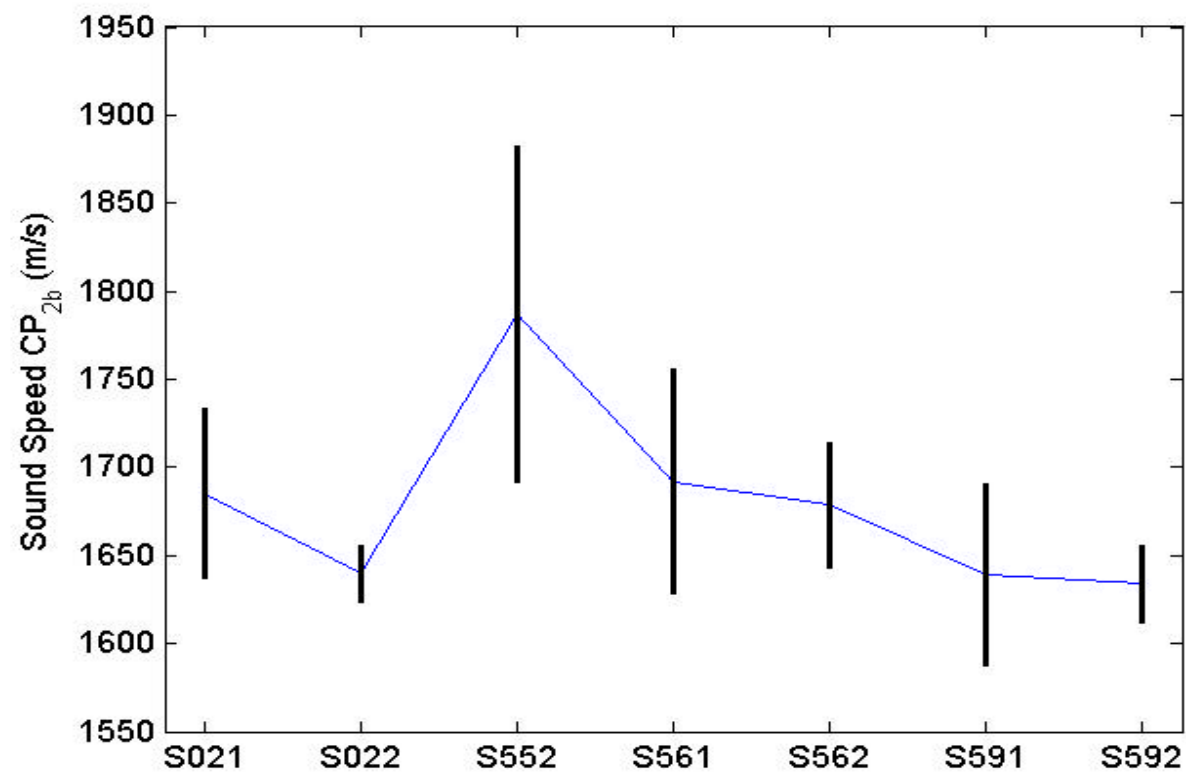
# Inversion Results

## – Medium Layer Sound Speed



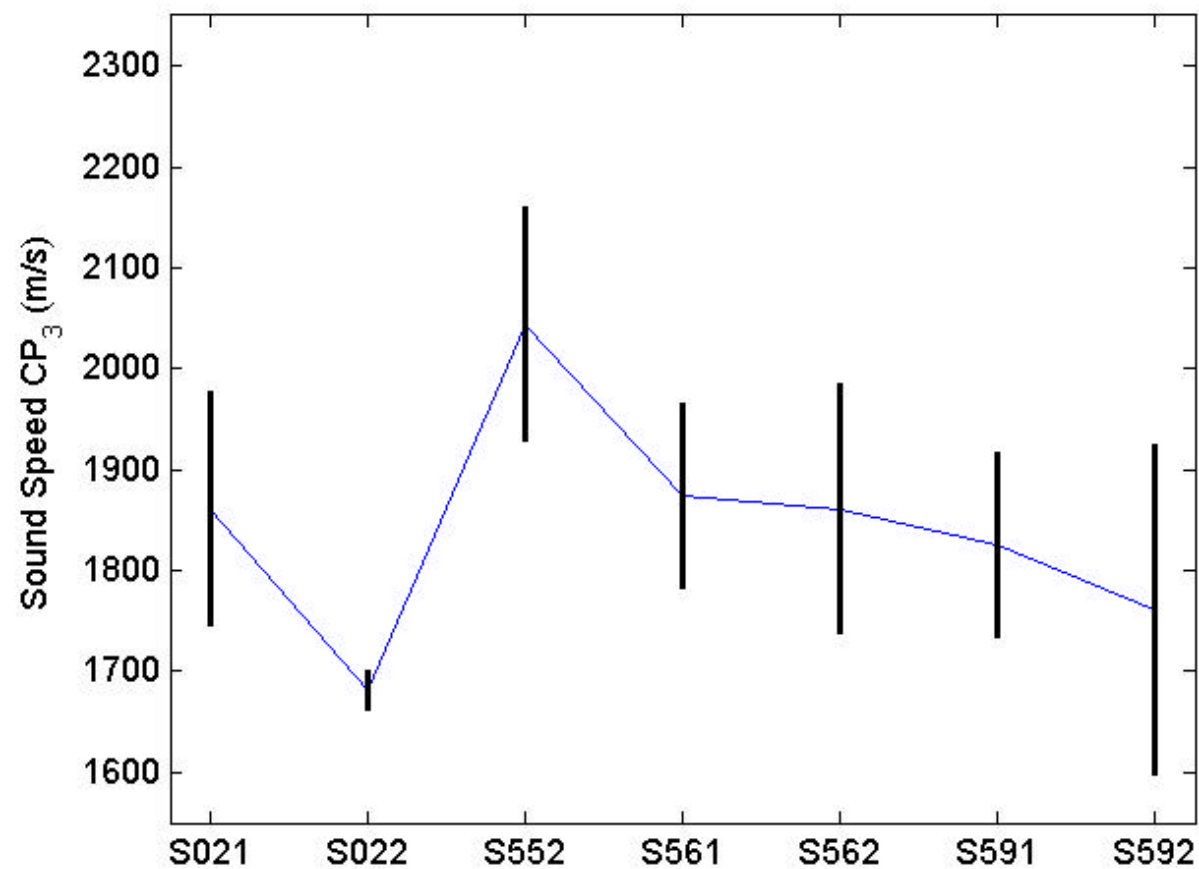
# Inversion Results

## – Medium Layer Sound Speed



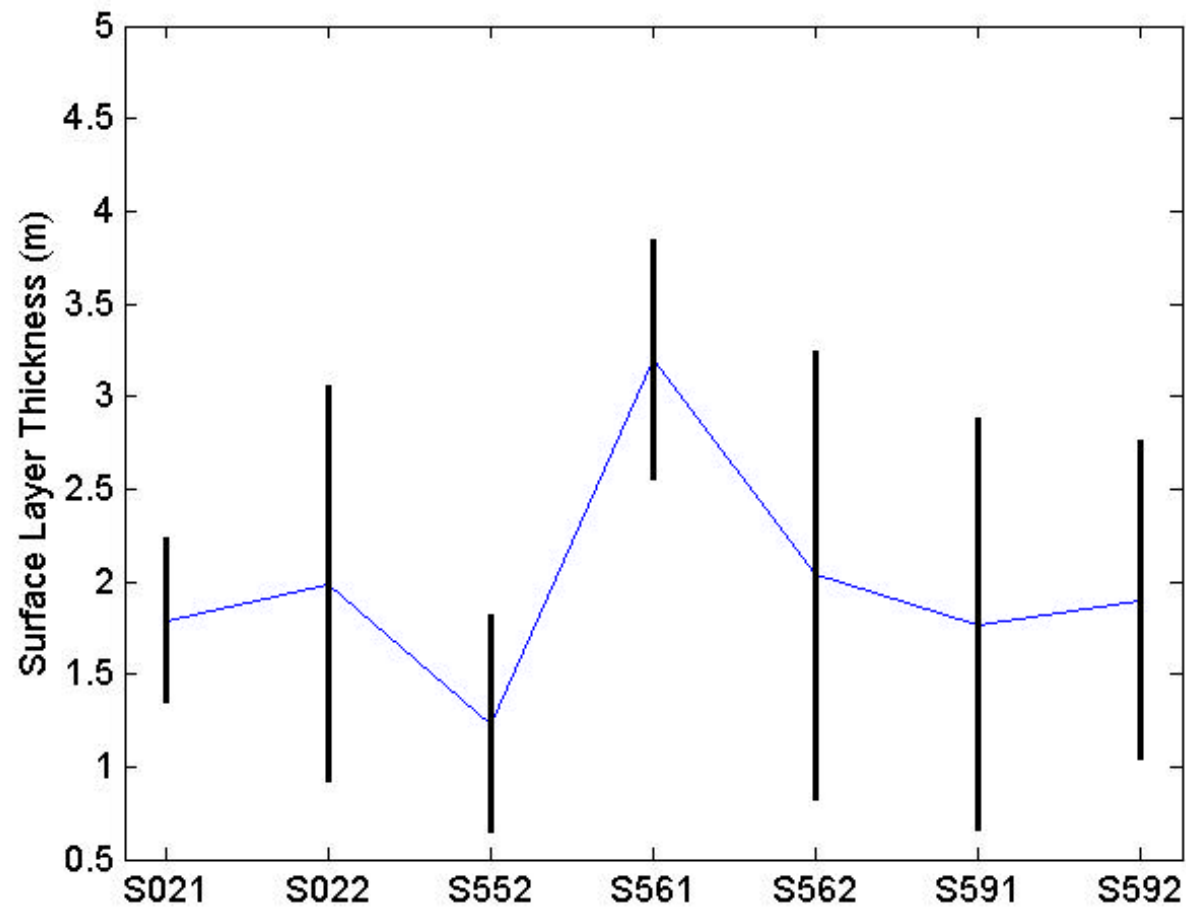
# Inversion Results

- Basement Sound Speed



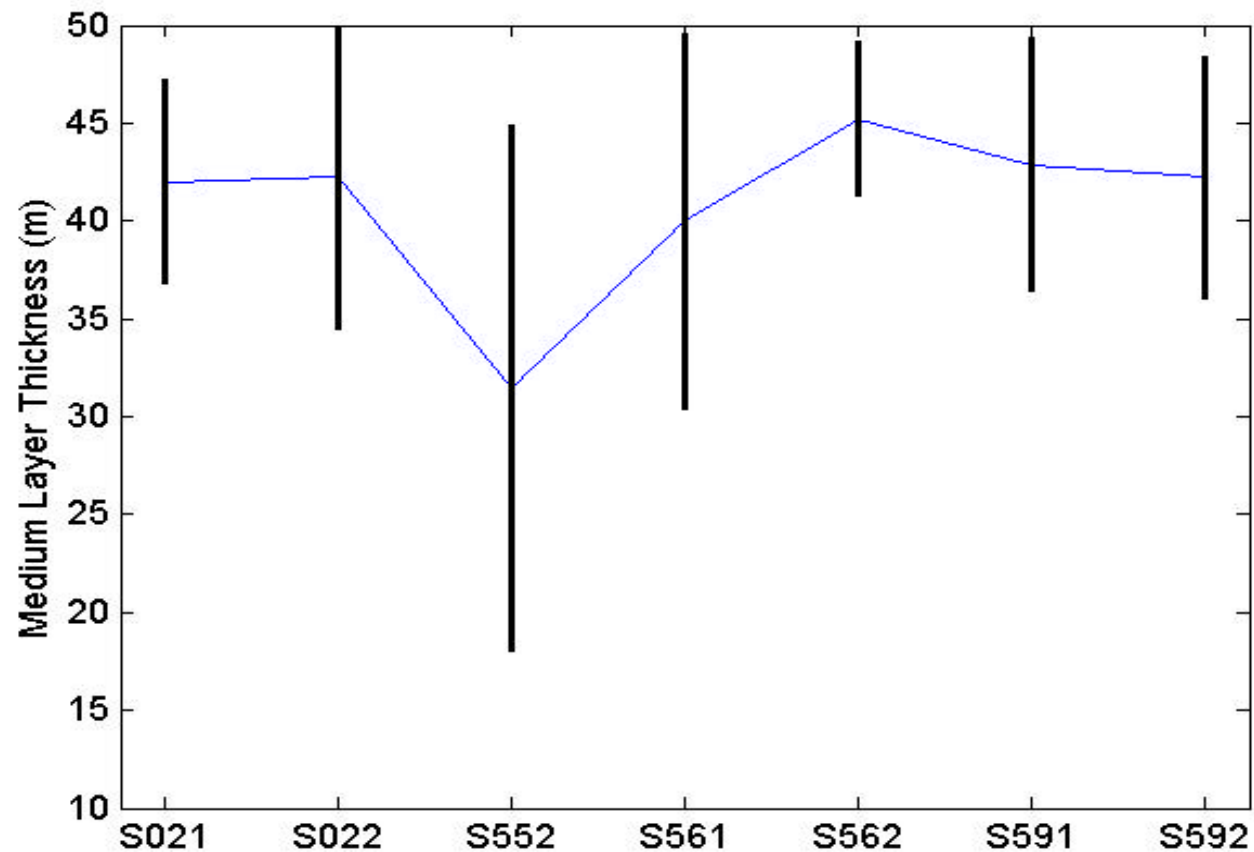
# Inversion Results

## – Surface Layer Thickness



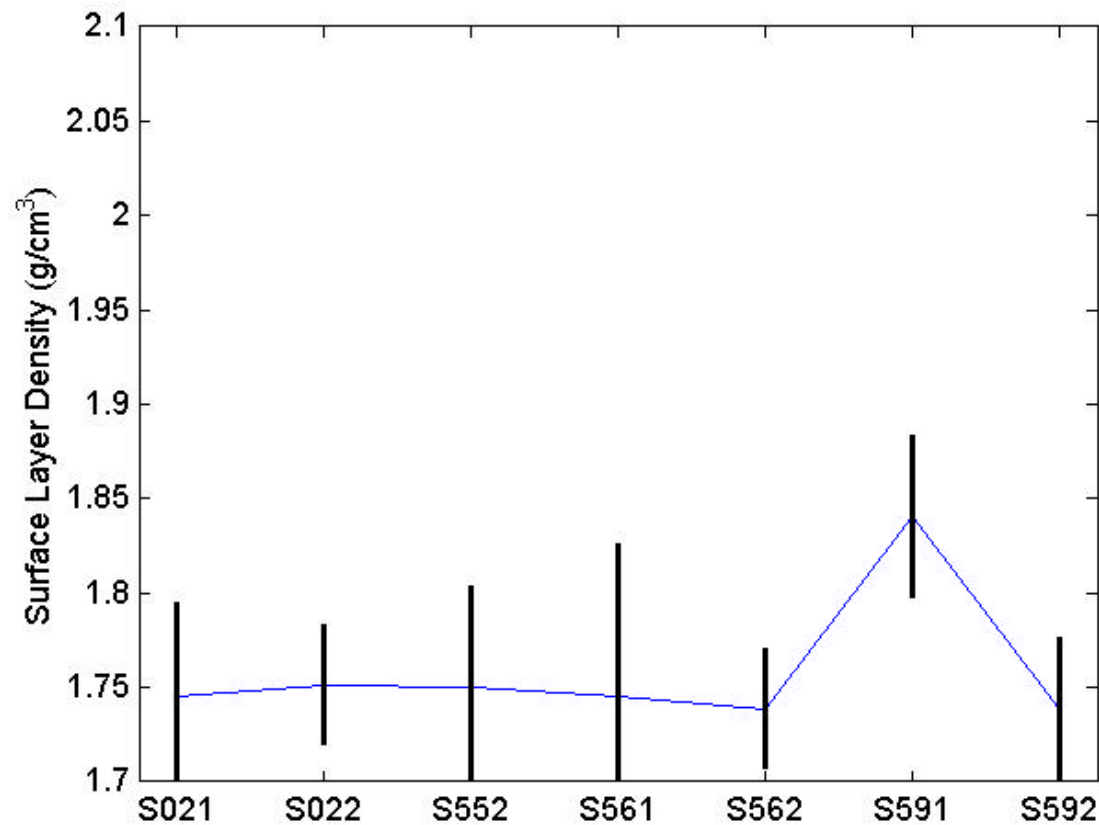
# Inversion Results

## – Medium Layer Thickness



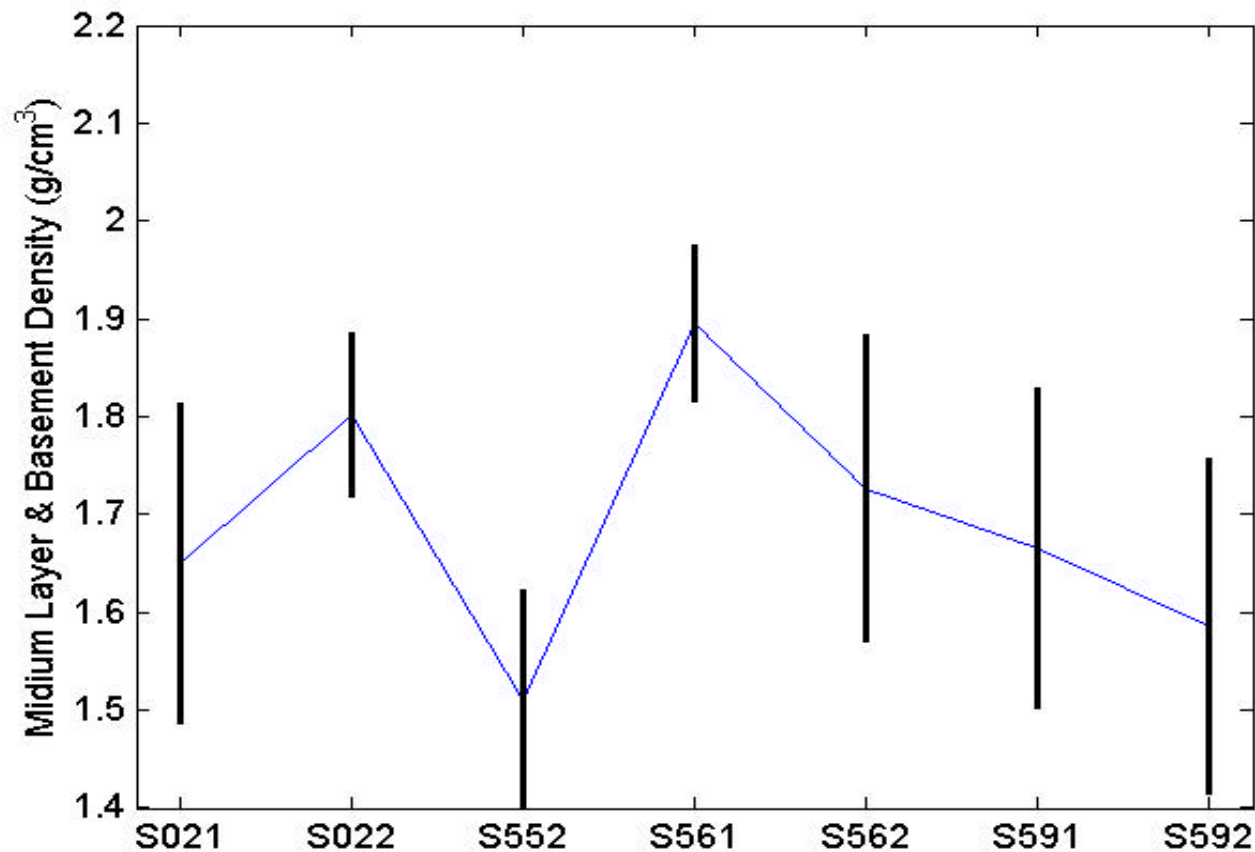
# Inversion Results

## – Surface Layer Density



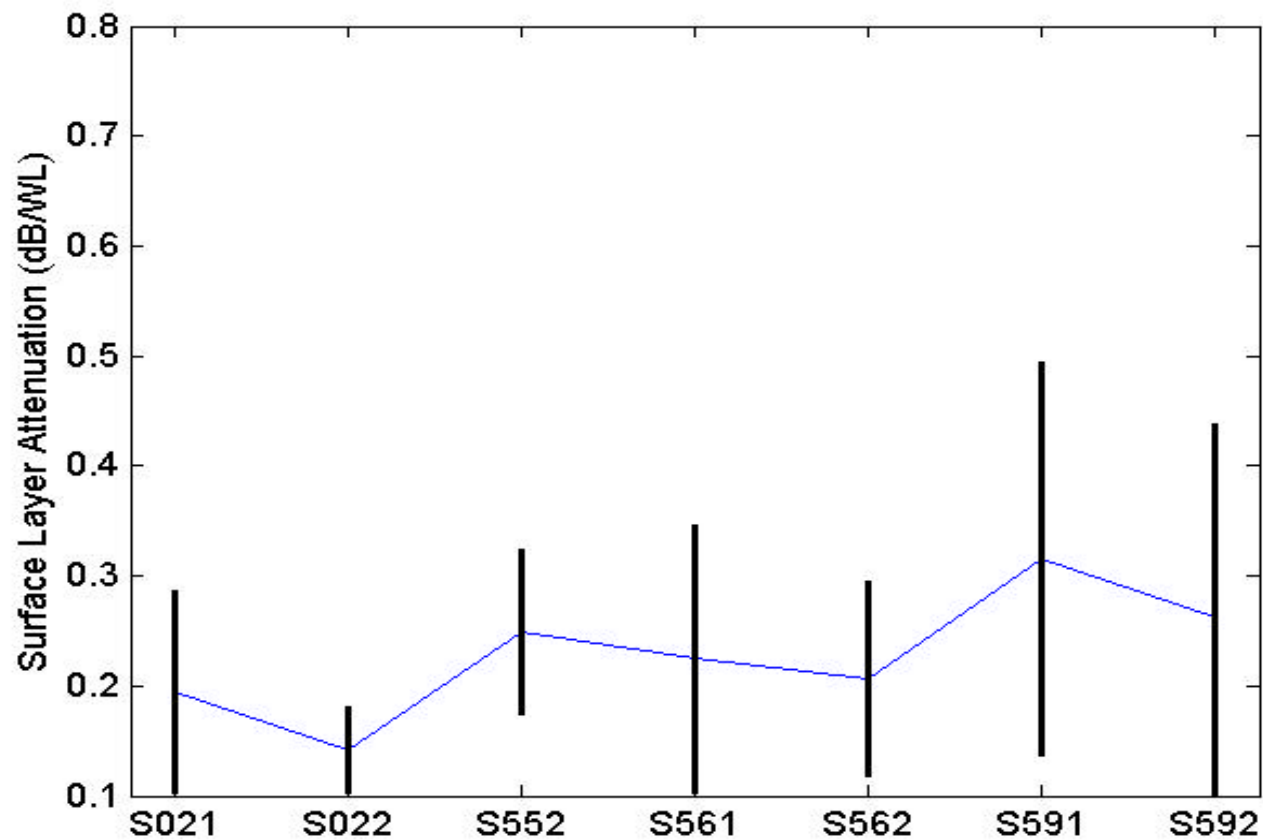
# Inversion Results

## – Medium Layer & Basement Density



# Inversion Results

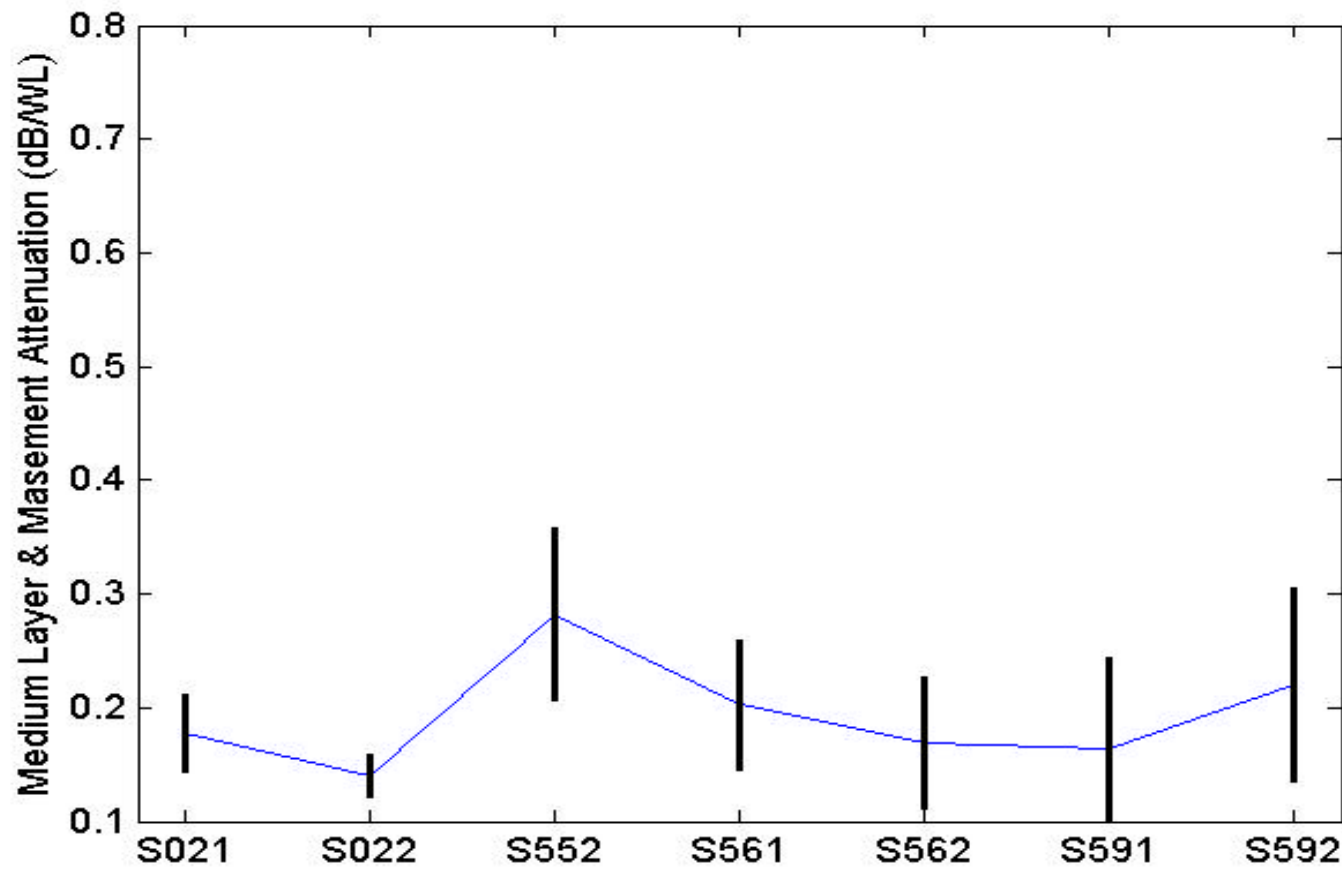
## – Surface Layer Attenuation





# Inversion Results

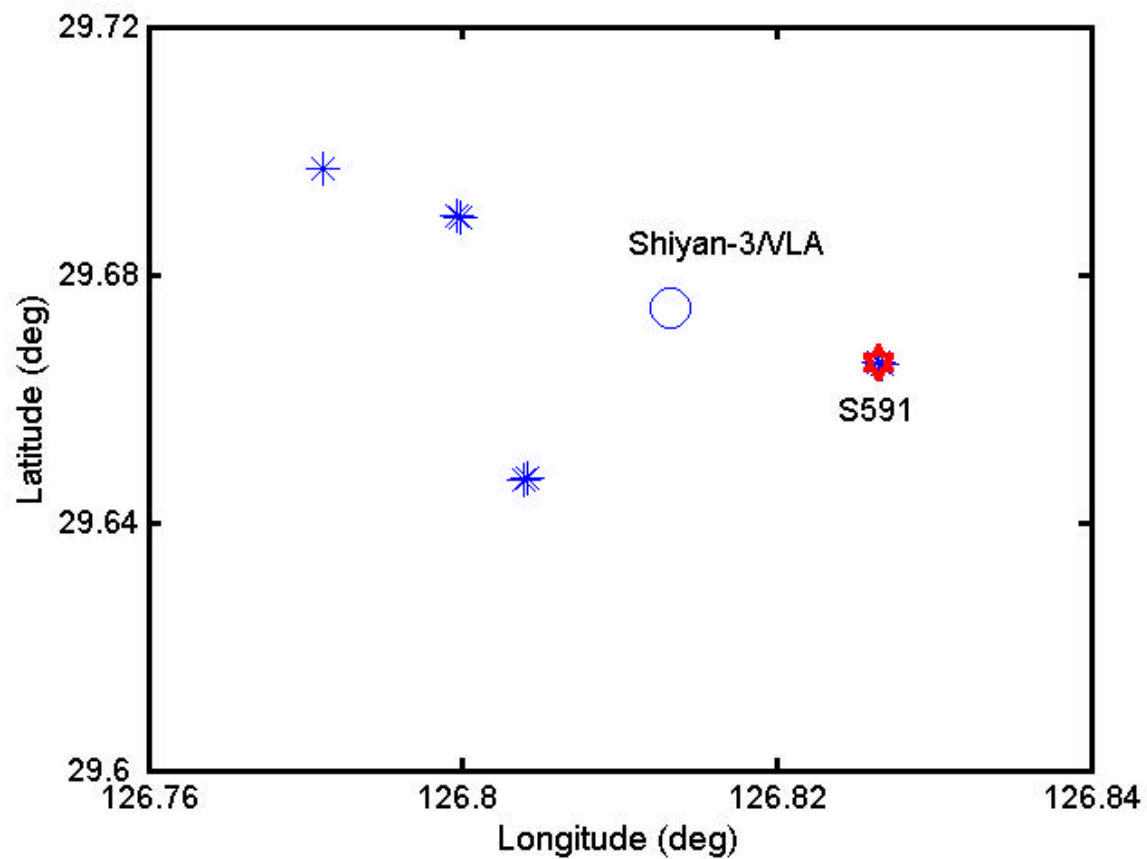
## – Medium Layer & Basement Attenuation



# Inversion Results of the Geo-acoustic Parameters

Parameter	Search Bounds	Step 1 results	
		Mean	STD
$CP_1$ (m/s)	[1550 1650]	1634	11.
$CP_{2a}$ (m/s)	[1550 1650]	1574	13.
$CP_{2b}$ (m/s)	+ [0 300]	1681	71
$CP_3$ (m/s)	+ [0 400]	1853	144
$\mathbf{r}_1$ (g/cm <sup>3</sup> )	[1.7 2.1]	1.76	0.05
$\mathbf{r}_2$ (g/cm <sup>3</sup> )	[1.4 2.2]	1.69	0.17
$\mathbf{a}_1$ (dB / $\mathbf{l}$ )	[0.1 0.8]	0.21	0.08
$\mathbf{a}_2$ (dB / $\mathbf{l}$ )	[0.1 0.8]	0.19	0.07
$H1$ (m)	[0.5 5.0]	2.0	1.0
$H2$ (m)	[10 50]	40.9	9.5

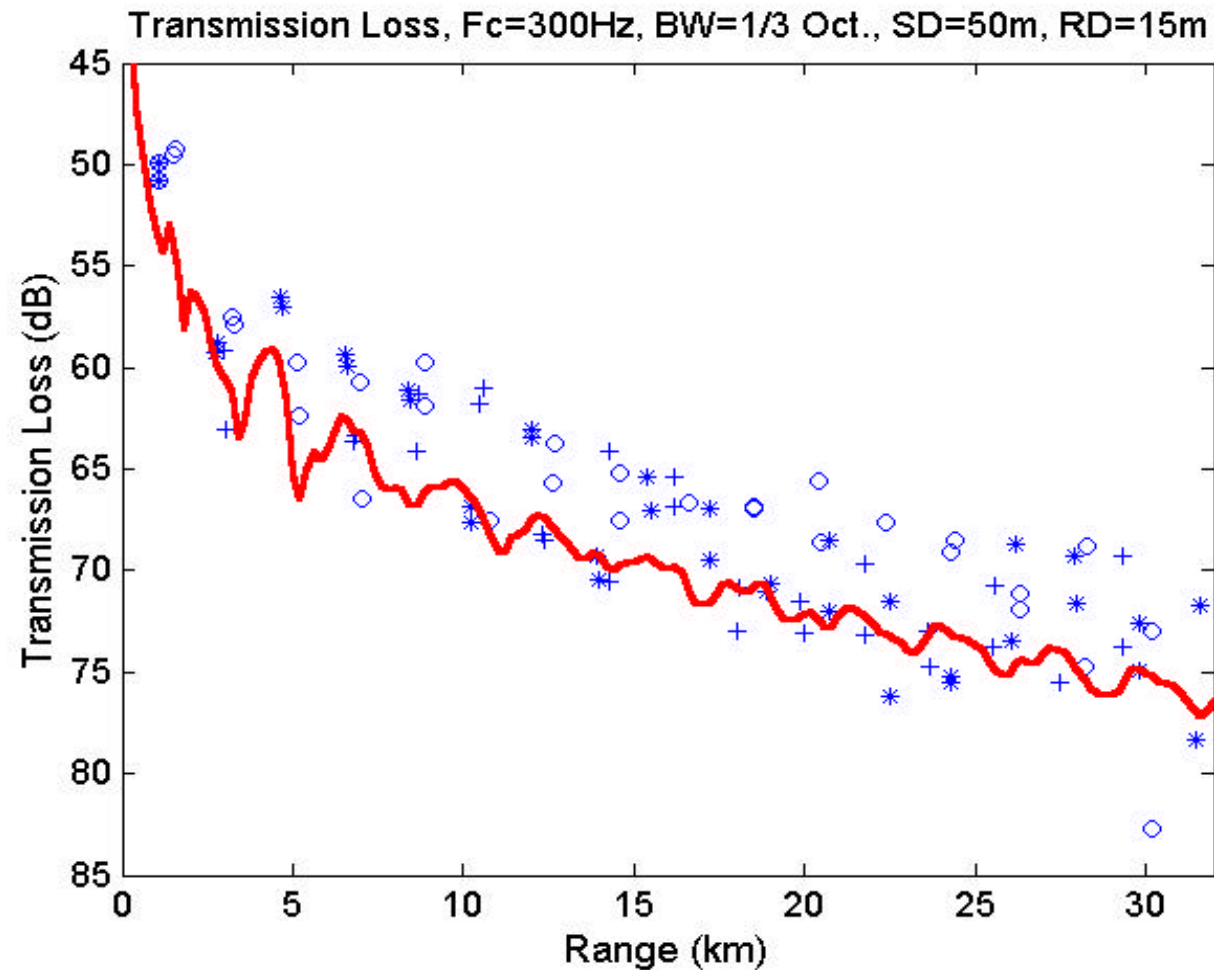
# The Bomb Signals from the Closet Range



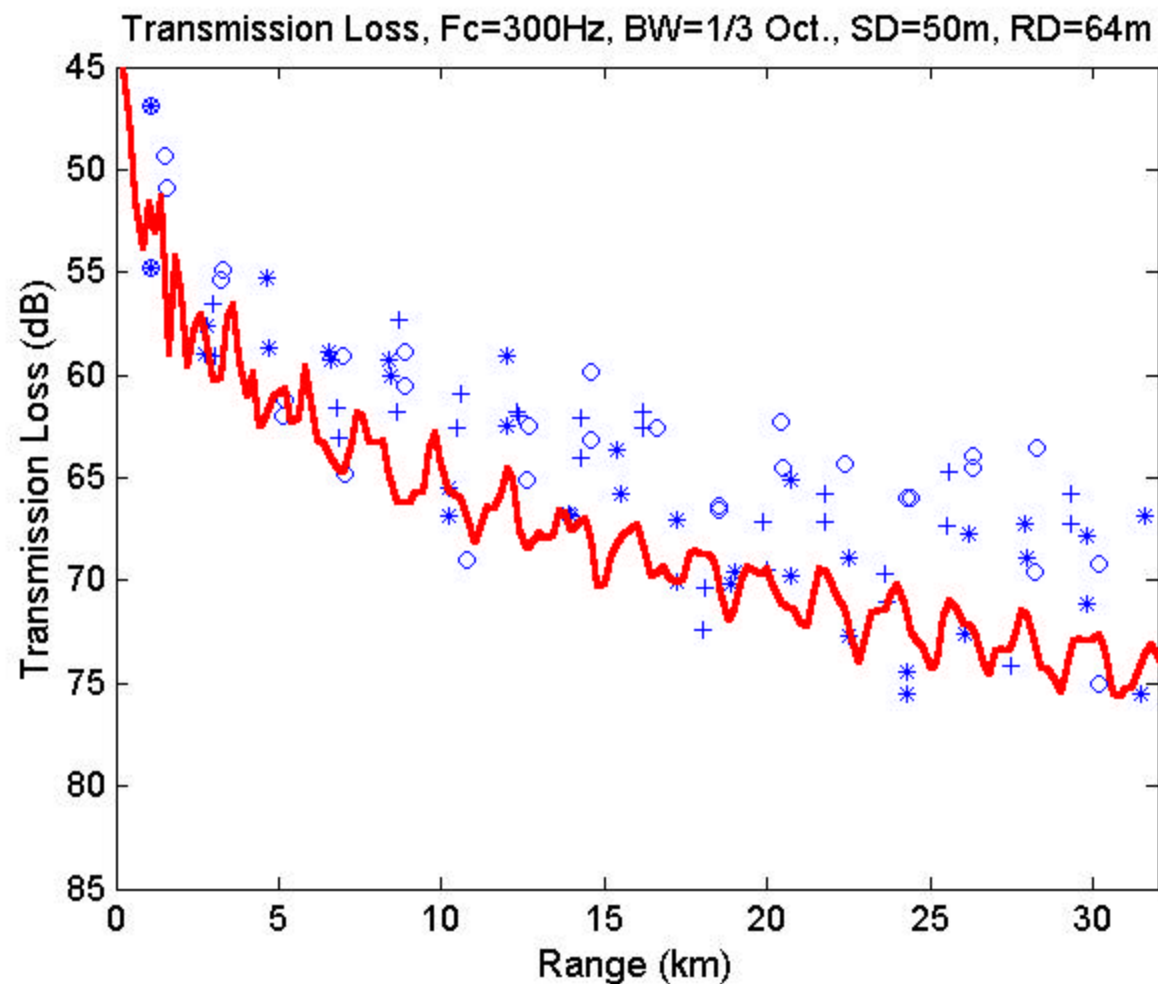
# Inversion Results of the Geo-acoustic Parameters

Parameter	Search Bounds	Step 1 results		Step 2 results	
		Mean	STD	Mean	STD
$CP_1$ (m/s)	[1550 1650]	1634	11.	-	-
$CP_{2a}$ (m/s)	[1550 1650]	1574	13.	-	-
$CP_{2b}$ (m/s)	+ [0 300]	1681	71	1648	22
$CP_3$ (m/s)	+ [0 400]	1853	144	1845	112
$\mathbf{r}_1$ (g/cm <sup>3</sup> )	[1.7 2.1]	1.76	0.05	-	-
$\mathbf{r}_2$ (g/cm <sup>3</sup> )	[1.4 2.2]	1.69	0.17	1.50	0.12
$\mathbf{a}_1$ (dB/ $\mathbf{l}$ )	[0.1 0.8]	0.21	0.08	-	-
$\mathbf{a}_2$ (dB/ $\mathbf{l}$ )	[0.1 0.8]	0.19	0.07	-	-
$H1$ (m)	[0.5 5.0]	2.0	1.0	1.5	0.4
$H2$ (m)	[10 50]	40.9	9.5	37.1	9.1

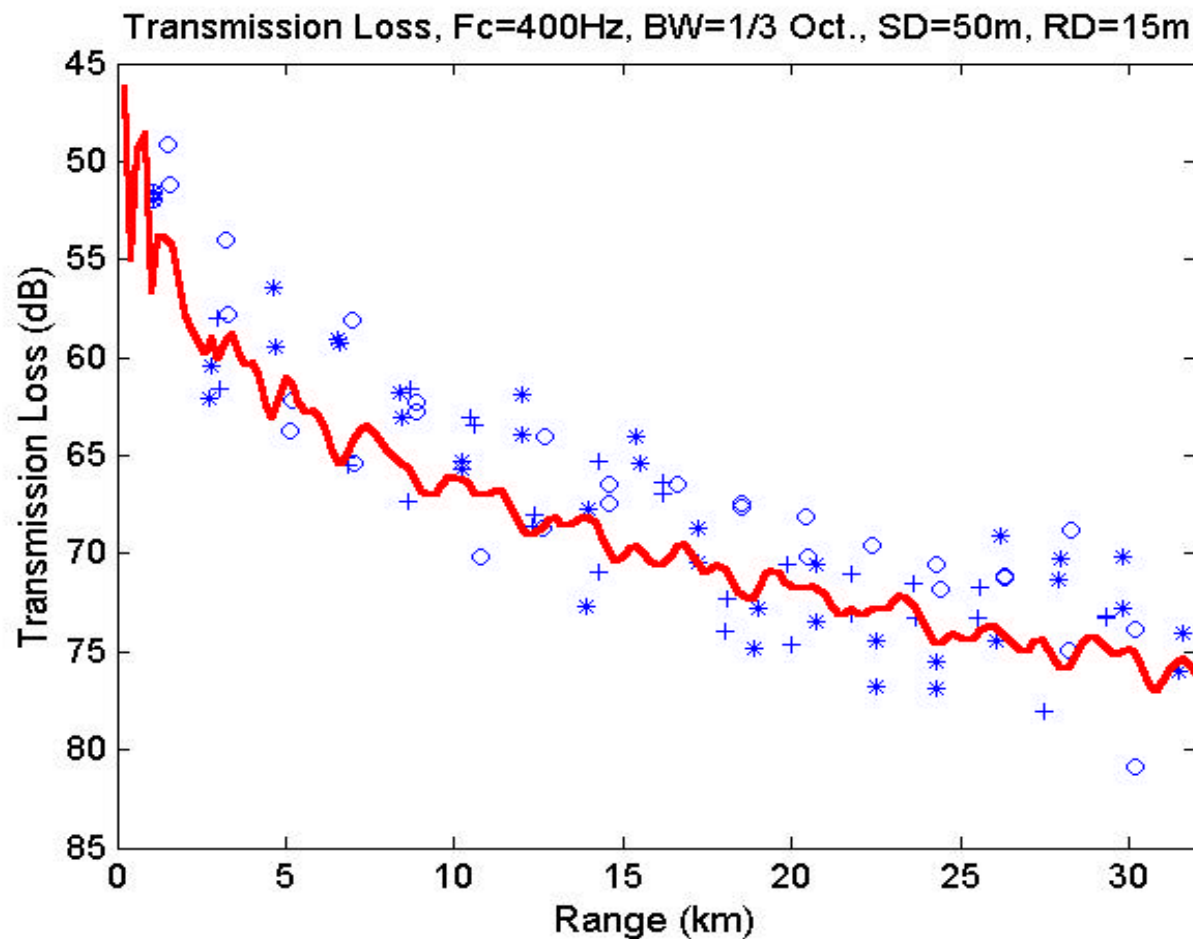
# Transmission Losses Calculated from the Inversion Results



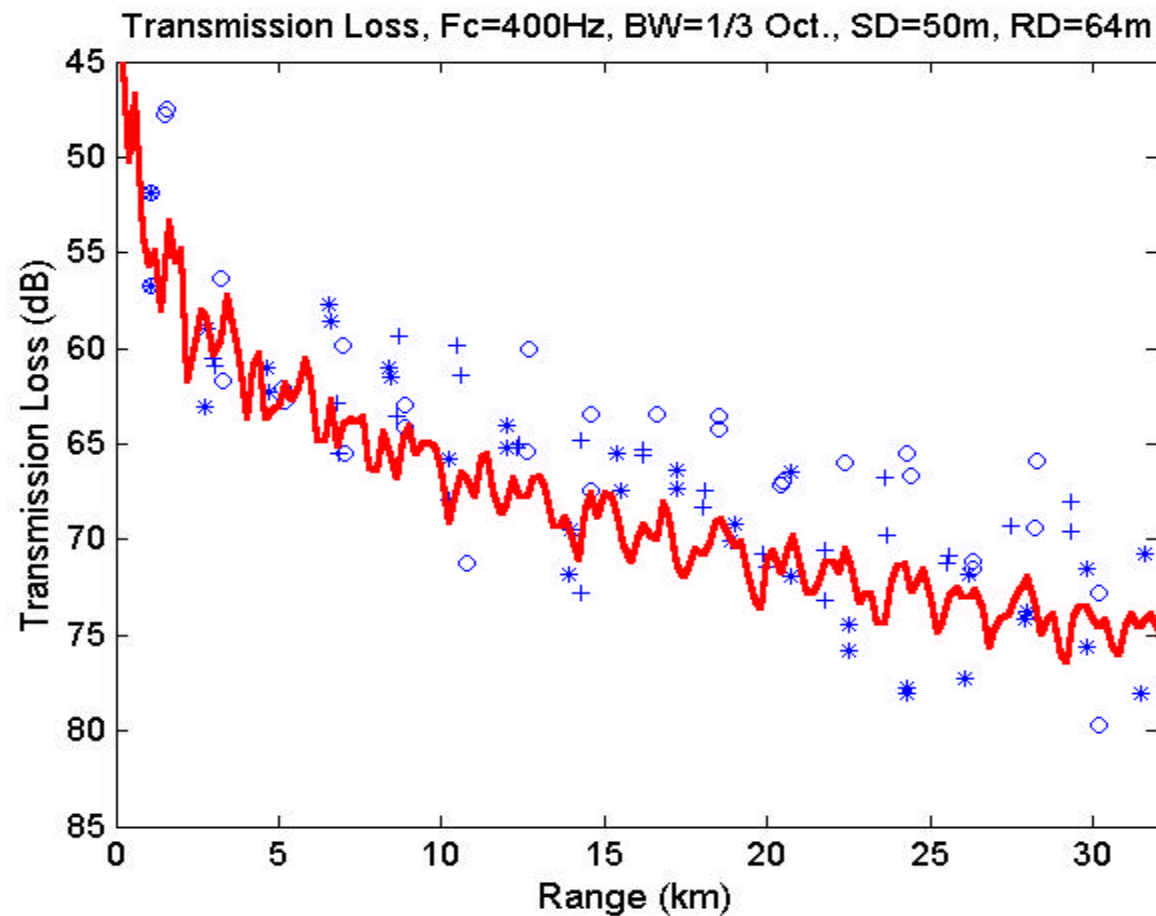
# Transmission Losses Calculated from the Inversion Results



# Transmission Losses Calculated from the Inversion Results



# Transmission Losses Calculated from the Inversion Results





# Conclusions

- 3-layer bottom model
- Sound speed, density and attenuation for the surface layer are about 1634m/s, 1.76g/cm<sup>3</sup> and 0.21 dB/WL, respectively. The thickness is about 1.5m.
- For the medium layer, the sound speed changes from 1574m/s to 1648m/s, and the thickness is about 37m.

Thanks!